(12) UK Patent Application (19) GB (11) 2 327 375 (13) A

(43) Date of A Publication 27.01.1999

(21) Application No 9814683.0

(22) Date of Filing 08.07.1998

(30) Priority Data
(31) 9715357 (32) 21.07.1997 (33) GB
(31) 9715359 (32) 21.07.1997

(71) Applicant(s)
Kvaerner Metals Continuous Casting Limited
(Incorporated in the United Kingdom)
Prince of Wales Road, SHEFFIELD, S9 4EX, United Kingdom

(72) Inventor(s)
Timothy Reynolds
Michael Steeper

(51) INT CL^6
B21B 1/46

(52) UK CL (Edition Q)
B3A A124

(56) Documents Cited

EP 0625383 A	EP 0499851 A	US 5611232 A
US 5579569 A	US 5533248 A	US 5430930 A
US 5396695 A	US 5150597 A	US 4829656 A

(58) Field of Search
UK CL (Edition P) B3A
INT CL^6 B21B 1/00
On line databases WPI,EDOC,JAPIO

(74) Agent and/or Address for Service
Neil Muttock
Hillgate Patent Services, No 6 Aztec Row, Berners Road, Islington, LONDON, N1 0PW, United Kingdom

(54) Abstract Title
Continuous metal manufacturing method and apparatus therefore

(57) The invention relates to a method for the manufacture of metal products, such as strip or lengths of rod or bar, from the molten metal to the final finished strip comprising a casting process 2 and a rolling process 4, wherein the casting process produces a long strand of solidified metal, which enters a temperature controlling furnace 3 and then sheared before it enters the rolling process 4, to produce a strand having a long strand finite length L which corresponds to the strand length required to produce at least one and preferably between 4 and 7 discrete desired final length of finished rolled product. Each strand enters the rolling process 4 and is threaded through the rolling stands 32 at a threading speed and which the speed is increased to a higher speed and the gauge of the strand is changed, by synchronously controlling the roll gaps and the speed of the rolling process, so that the gauge of the first discrete finished strip length is larger than the gauge of at least one subsequent finished strip length.

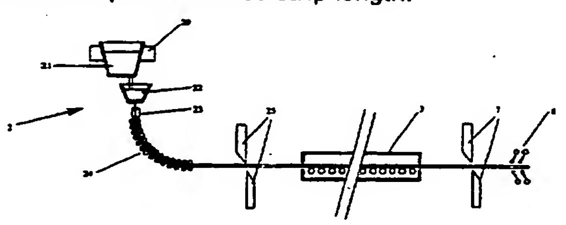

Figure 1.

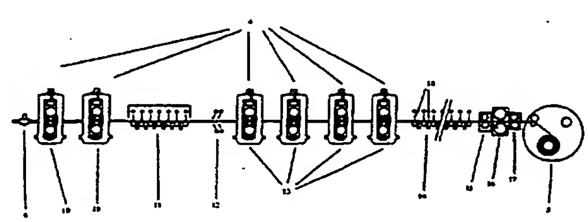

Figure 2.

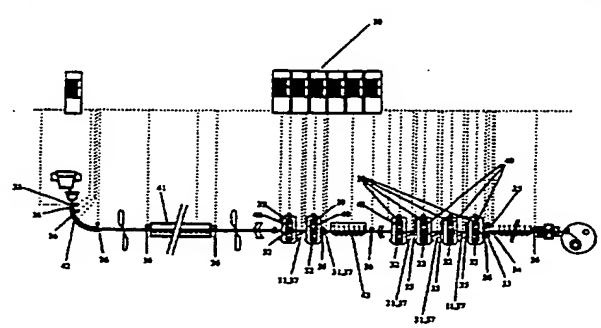

Figure 3.

BEST AVAILABLE COPY

GB 2 327 375 A

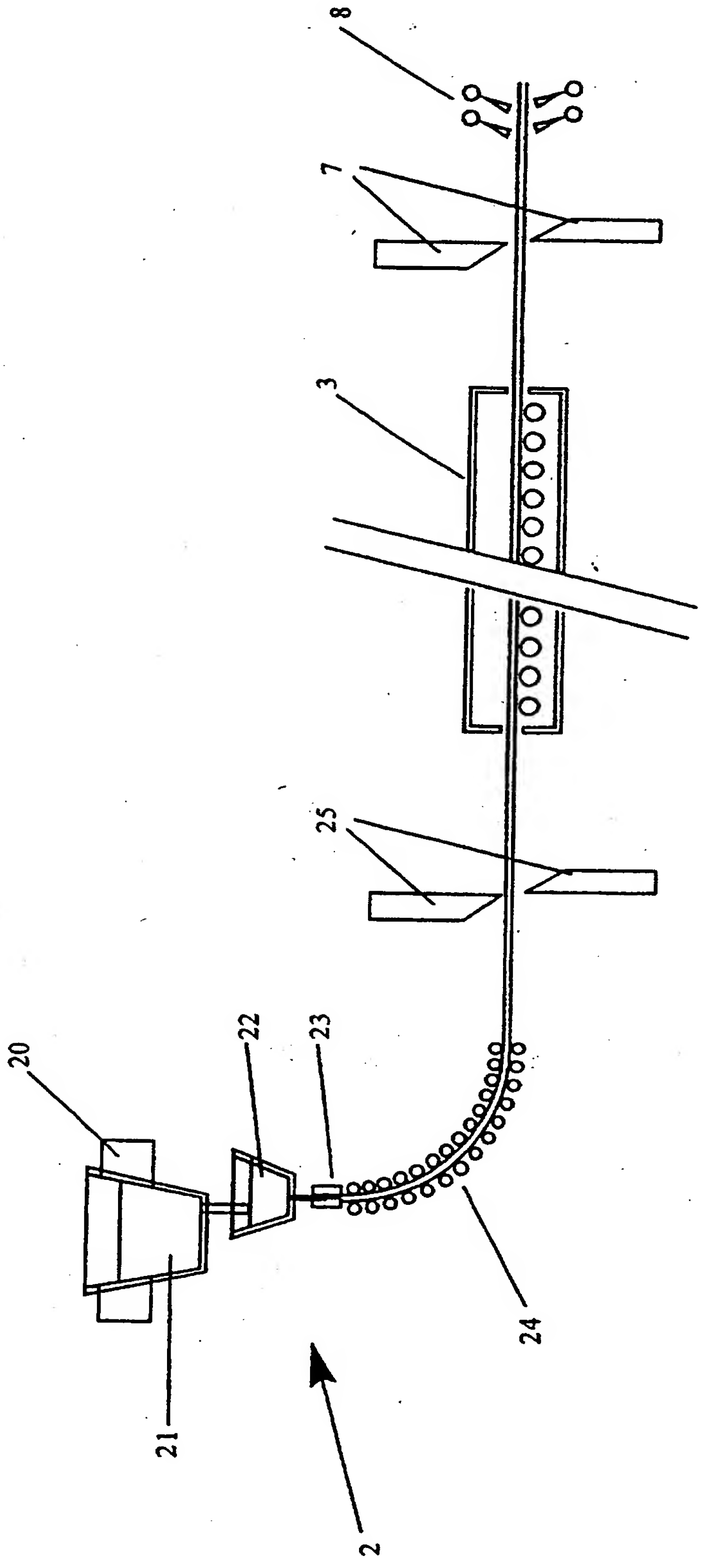

Figure 1.

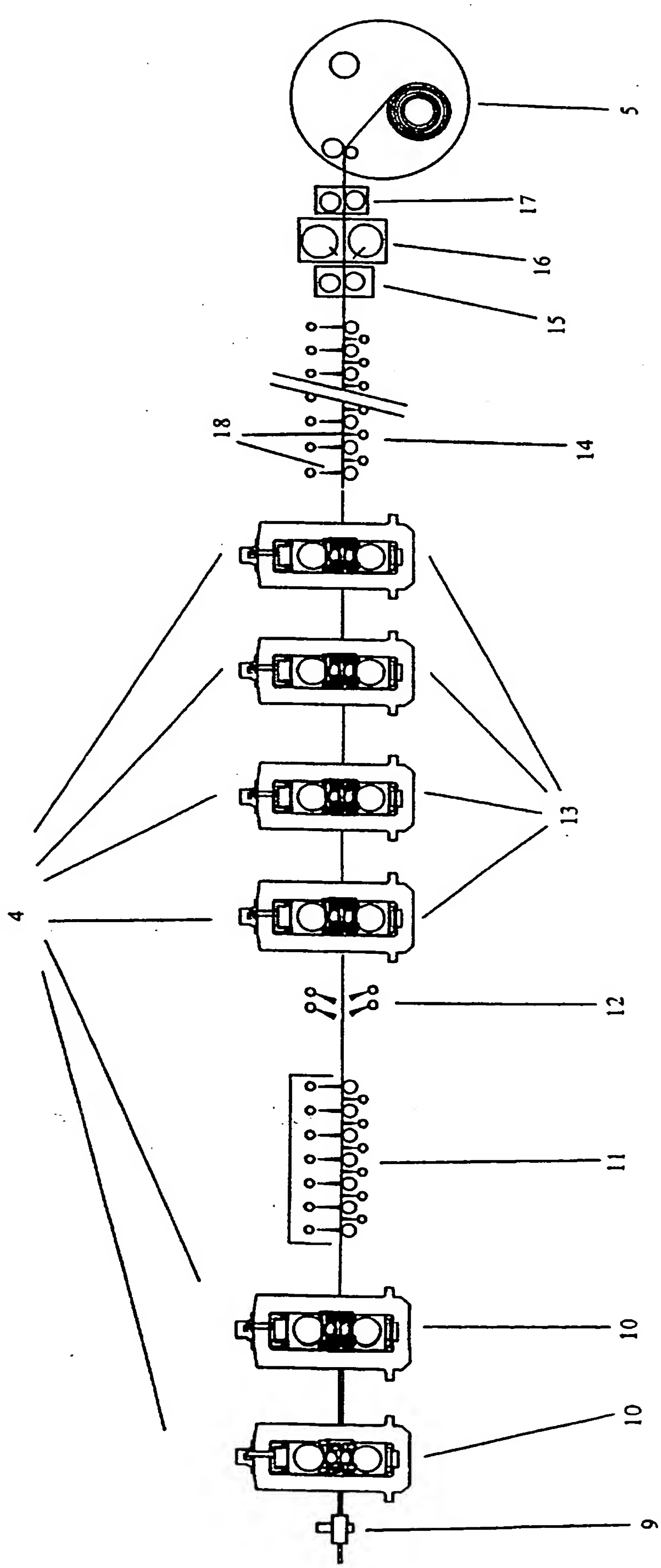

Figure 2.

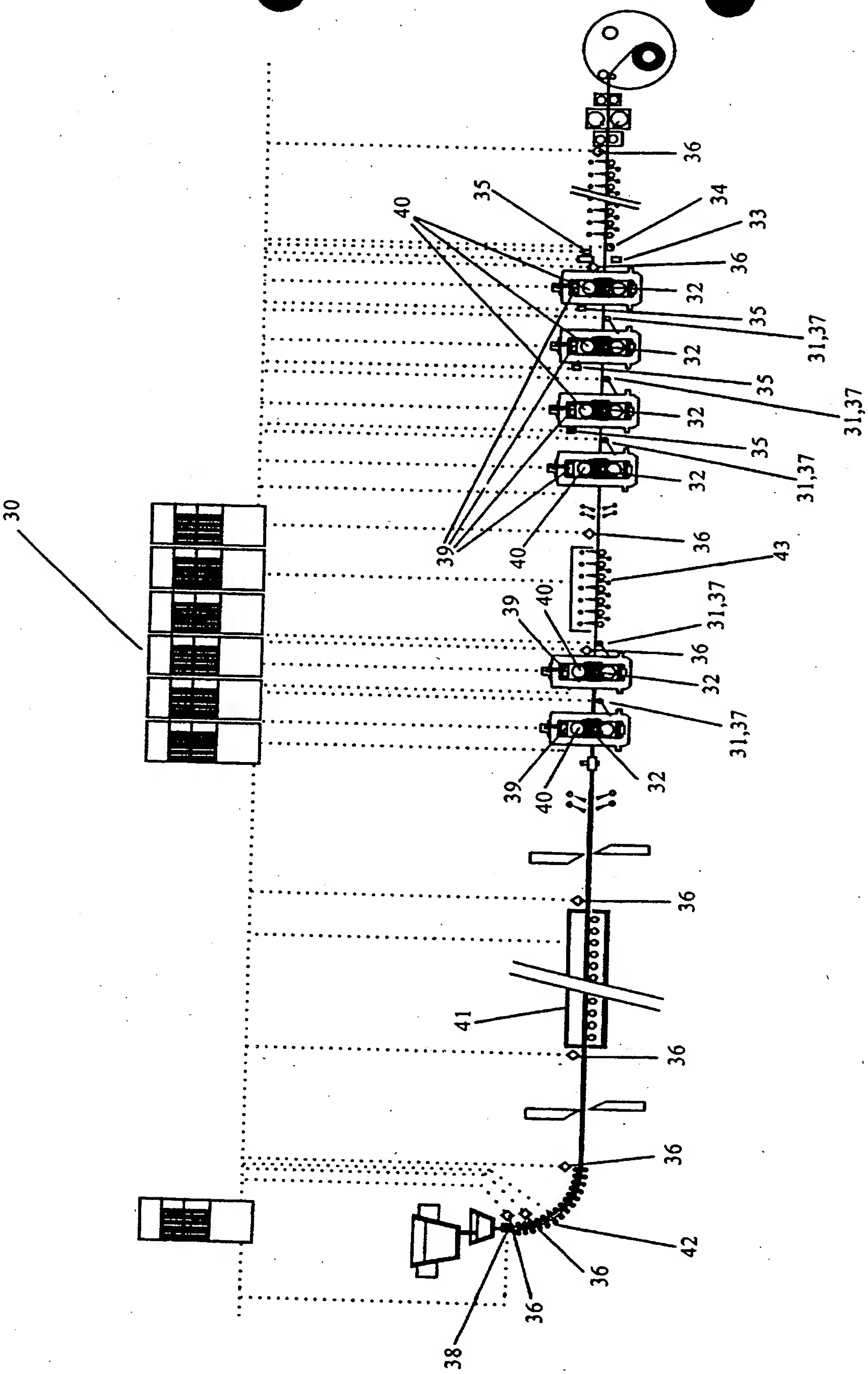

Figure 3.

requires significant energy input to maintain the slabs at the required temperature for rolling.

According to conventional methods the continuously cast strand is cut into lengths which correspond with the final length of the hot rolled product as delivered from the mill in coil form. The mill has a maximum coil weight capability and the maximum cut strand piece corresponds to this weight with an allowance for discards made during processing. For some products the mill will subdivide the products into shorter lengths before delivery.

Because the mill usually rolls at a faster production rate than the caster casts, the pieces are processed through the mill with gaps in the processing between pieces. This allows product from other caster strands to be introduced. Because the mill rolls discrete lengths, one or more discrete coilers are utilised with time to discharge the full coil before the next coil is processed.

It is therefore an objective of the invention to provide a continuous or semi continuous casting and rolling of steel strip, rod or bar.

It is a further objective of the invention to provide gauge changes whilst the casting and rolling operation is in progress to reduce the down time or lost production time for gauge specification changes.

A consequential objective of the invention is to reduce the assets tied up in the casting and rolling processes and decrease the minimum optimum order size and to increase the flexibility of production and reduces the processing time.

It is also an objective of the invention to provide an apparatus and a method of semi-endless coupled casting and rolling of strip, in particular of thin gauge metal strip, which does not damage the edges of the strip.

According to the invention there is provided a method for the manufacture of metal products such as strip or lengths of rod or bar, from the molten metal to the final finished strip comprising a casting process and a rolling process, wherein the casting process produces a long strand of solidified metal, and wherein the solidified metal enters a temperature controlling furnace before it enters the rolling process, characterised in that the long strand of solidified

2327375

CONTINUOUS METAL MANUFACTURING METHOD AND APPARATUS THEREFOR

The present invention relates to a continuous metal manufacturing method and apparatus therefor and in particular of steel.

Conventionally steel strip, rod or bar has been made by casting discrete slabs of steel in the foundry or steel making plant and transferring the slabs to a rolling mill where they are progressively rolled in a series of rolling mill stages or stands. The slabs will typically be re-heated before the rolling commences. The slab may be passed back and forth through a first rolling stand before the required reduction in thickness is achieved before proceeding to the next rolling stand. As the slab is progressively rolled its section is reduced and its length increased and in the later rolling stands the slab becomes a long strip and will enter the subsequent rolling stand before leaving the previous stage. The speeds of these rolling stands will therefore have to be matched. A degree of looping of the strip between the stages is conveniently permitted in order that there is some tolerance in the matching of the speeds of the respective stages. For strip the final strip of the desired thickness and width is coiled at a coiling stage and each coil will correspond to the respective slab from which it was made.

With the recent development of continuous casting, conventionally the casting and rolling operations have continued to be separate discontinuous processes. This is convenient because the processing speeds for the casting and rolling processes are different. The output of a rolling mill is typically faster than the output of the casting process. Also down time for the rolling mill is usually much more frequent than that for the casting process and the caster machine is generally able to continue operating for a larger number of producing hours per year than a rolling mill. These differences in rates are typically managed by the holding of a small buffer stock between the caster and the mill. This buffer stock is part of the total amount of work in progress which contributes to the assets tied up in the process. It also adds to the total amount of material tied up in a particular order for a particular size and type of material strip, and also

metal is sheared before the rolling process in order to produce a strand having a finite long strand length (L) which corresponds to the strand length required to produce at least one discrete desired final length of finished rolled product.

Preferably the long strand length corresponds two or more discrete lengths of finished rolled product and most preferably the long strand corresponds to between 4 and 7 discrete lengths of finished rolled product.

The long strand length may correspond to the volume of molten metal in a single ladle from which the long strand has been cast.

Preferably each strand enters the rolling process and is threaded through the rolling stands at a threading speed and that after the strand has been threaded through the rolling stands the speed is increased to a higher rolling speed and the gauge of the strand is changed, by synchronously controlling the roll gaps and the speed of the rolling process, so that the gauge of the first discrete finished strip length is larger than the gauge of at least one subsequent finished strip length.

Preferably a gauge or shape change of the strand is achieved using dynamic shape roll (DSR®) rolls having shells which are deformable to provide a controlled profile to produce the desired flatness of the strip.

Preferably two casting lines are provided to provide strands for the rolling process each casting line being provided with a ladle positioning means, a casting tundish, a mould and a strand support and wherein the temperature controlling furnace is a tunnel furnace which includes at least one heat adding zone, including a temperature increasing zone and/or a temperature maintaining zone.

Preferably the rolling process includes a first rolling stage and a second rolling stage, wherein a cooling stage is provided, for steel strip, between the first rolling stage and the second rolling stage to allow the transformation of steel from the austenitic phase to the ferritic phase so that the transformation takes place before, subsequent rolling.

Preferably the steel is cooled by air assisted water based cooling means.

Preferably the apparatus includes a control system with means for measuring the speed of the strip and the strands as well as a profile measuring means, a shape measuring means, and means for measuring the thickness and width of the strip and also the lateral position of the strip.

The control system may be linked to temperature measuring sensors in a plurality of locations along the strand and strip as well as tension measurement means in the rolling process.

Preferably the control system is linked to a plurality of actuators in an integrated actuating system which operate in response to the measured parameters.

Preferably the speed and tension of the strip is controlled by the roll speeds, and the profile, shape, gauge, width and lateral alignment is controlled by the mould, roll gap, actuating means such as Dynamic Shape Roll (DSR) rolls or by guide rolls.

There now follows a more detailed description of a specific embodiment of the method and apparatus according to the invention with the aid of the attached drawings in which:

Fig. 1 is a side view of the first part of the apparatus of an embodiment of the invention shown in schematic, and

Fig. 2 is a side view of the second part of the apparatus of the embodiment of Fig. 1.

Fig. 3 is a schematic view of the apparatus and control system of an embodiment of the invention.

Referring to Fig. 1, 2 and 3 an apparatus of one embodiment of the invention is shown for manufacturing metal strip. In this embodiment the metal strip is steel strip. The molten steel is formed into the final finished strip by means of the

combined casting process stage 2, an intermediate temperature controlling furnace 3, a rolling process stage 4 and a final coiling stage 5.

The casting process stage 2 comprises a positioning means 2 0for positioning a ladle 21over a casting tundish 22. The tundish 22 may be a conventional bath type tundish or an alternative tundish such as an H type tundish. The tundish 22 deliveries the molten steel into the mould 23 in which the steel solidifies into a continuous strand. The mould 23 may be of the funnel type or alternatively the plain type mould and provides changes to and control of the width. On exiting the mould the strand then enters a strand support 24 which ensures that the strand is maintained in a desired shape and provides the required bending and straightening of the strand. It is also possible to include some strand reduction at this stage to reduce the cross sectional dimensions of the strand.

The next stage is a strand shear 25 which shears the strand length into the desired length which corresponds to the desired number of final lengths of coiled finished strip.

The strand length then enters the tunnel furnace 3. The purpose of the tunnel furnace is to ensure that the strand is at the required temperature for the subsequent rolling operation. The required temperature of the strand depends therefore on the further processing requirements of the final strip and thus additional heating may be required as well as maintenance of the desired temperature by means of soaking in a heat adding stage of the furnace or possibly merely by heat insulation. Also at the tunnel furnace a second continuous cast strand could be introduced from a separate casting unit so that the generally slower throughput of the casting unit can be balanced with the generally higher throughput of the rolling process so that the throughput capacity of the rolling process is more fully utilised.

In the embodiment shown in Fig. 1 an optional emergency shear 7 is provided at the exit of the tunnel furnace which may be needed in the event of a problem in the rolling process to make a required cut through the strand.

Preferably two casting lines are provided to provide strands for the rolling process each casting line being provided with a ladle positioning means, a casting tundish, a mould and a strand support. Thus the throughput capacity of

the casting lines can be balanced with the throughput of the rolling line to achieve the maximum possible capacity utilisation for the combined investment in the entire facility. The temperature controlling furnace 3 is a tunnel furnace 3 and may be provided for each caster or may be a single furnace arranged at the start of the rolling process. The temperature controlling furnace 3 includes at least one heat adding zone, including a temperature increasing zone and/or a temperature maintaining zone.

The next two stages of the strip-making apparatus are a de-scaling stage 8, shown on Fig. 1 and an edging stage 9 shown on Fig 2. The edging stage 9 is optional and may not be necessary for certain kinds of metal strip specifications.

The strand now enters the rolling process stage 4 which in this embodiment includes a first roughing rolling stage which includes two roughing rolling stands 10 separated by a scale suppression stage between them.

The next stage is a cooling stage 11 which is not necessary for all strip product specifications but preferred for certain types of steel strip to allow the transformation of the steel from the austenitic phase to the ferritic phase so that the transformation takes place before further rolling rather than during subsequent rolling. Stage 12 is an additional descaling stage.

When ferritic rolling is required the steel is cooled by air assisted water based cooling means in-line with out interrupting the throughout. The cooling means therefore need to be able to provide an effective rapid cooling of the strip within a short distance. The cooling proposed by the invention is by means of jets of water based coolant which is propelled by a flow of compressed air to produce jets of a mixture of air and a water based coolant.

Rolling stage 13 is the finish rolling stage with four rolling stands in this embodiment although more stages may be required in other embodiments. Preferably low inertia hydraulic loopers are provided (not shown) and also optional scale suppression between each stand.

The rolled strip is then fed to a run out table 14 which may also be provided with optional cooling 18, in addition to normal air cooling.

A first pinch roll 15 is provided in front of the shear 16 which is followed by a separate optional pinch roll 17 and then a coiling stage 5, all of which enable the desired final strip lengths to be cut and coiled whilst being continuously fed from the mill.

The apparatus includes a control system 30 with means for measuring the speed of the strip 31 and the stands 32, as well as the profile 33, shape 34, thickness 33 and width 35 of the strip and also the lateral position of the strip 35. The control system is also linked to temperature measuring sensors 36 in numerous places along the whole apparatus as well as tension measurement 37 in the rolling process.

The control system is linked to actuating systems which vary all of these parameters. The speed and tension of the strip are controlled by the roll speeds 32, and the profile, shape, gauge, width and lateral alignment are controlled by the mould 38, the roll gap actuators 39, actuating means such as Dynamic Shape Rolls 40 and by guide rolls. The temperature is adjusted by the heating means in the tunnel furnace 41, cooling means at the caster 42 and by cooling sprays at the cooling stage 43 and/or at the rolling stands.

Most of these parameters are interdependent and the control system takes into account consequential effects on the other parameters. The gauge of the strip may be changed during the rolling process by controlling the roll gaps and the speed of the whole casting and rolling process in a synchronous way.

The shape change is preferably achieved using dynamic shape roll (DSR) rolls having shells which are deformable to provide a controlled profile to produce the desired flatness of the strip. This may be combined with crossed rolls or other actuating means which are used to change the effective roll crown.

Preferably the long strand length corresponds to more than one complete cut finished product length and will preferably correspond to 4 to 7 finished product lengths. The long strand length may correspond to the volume of molten metal in a single ladle from which the long strand has been cast.

As each strand enters the rolling process it has to be threaded through the rolling stands and this occurs at a threading speed which is lower than the desired final rolling speed. This lower threading speed is equivalent to the speed as is presently used in the conventional rolling of strip from slabs or strand lengths rolled from cast slabs but will be the highest speed practical using this conventional method. With the present invention, however, after the strand has been threaded through the rolling stands the speed is increased significantly. Also the strand is very long, compared to conventional single cast slab strands, and rolling can thus take place at this higher speed in conditions which are at or very near steady state conditions. As a result of this higher speed and shorter processing time, the temperature of the strip during rolling is higher than during threading or during rolling of conventional cast slab lengths. This allows thinner gauges to be produced.

Thus once threaded the strip is passed through the rolling process under tension to produce the thinner gauges of strip. Thus by means of the present invention each strand will have to be threaded separately through the rolling process at the lower threading speed and at the relatively higher gauge of strip. Thus the production efficiency of the process can be maximised by producing the first length of strip at a desired relatively larger gauge and when the desired length of this first length of relatively higher gauge strip has been produced the gauge is changed during rolling by synchronous change to the rolling parameters to produce subsequent lengths of the desired lower gauge of strip.

The guidance of thin strip cannot be achieved in the same way as for thicker strip by means of physical edge guidance because it is not effective and it damages the edges of the strip. Instead, according to the invention, edge guidance is provided by roll tilting which is controlled based on measurements of the lateral position of the strip.

Also, for thin gauge strip for a given strip width the width/thickness ratio is higher and it is more difficult to achieve good flatness quality. By means of the invention the application of for example Dynamic Shape Roll (DSR) rolls with segmented internally actuated supports are provided to achieve the required flatness for thin gauges.

Also, the tolerance for crown on very thin strip is more demanding. Additionally when a gauge change during rolling is undertaken there is a requirement for a larger dynamic range of crown control actuation. This control is provided by DSR rolls, crossed roll arrangements where the rolls are crossed to change the effective roll crown or other convenient actuating means.

Also, when rolling very thin strip very small forces are required to generate the necessary strip tensions which are an integral part of the control of the whole process. Special loopers 31 are used between the rolling stages 13 to generate the required tension. The loopers must be of low inertia in order to apply the necessary small forces in a controllable way in conjunction with a fast response control system. This is provided by hydraulically actuated loopers together with load cell measurement of the forces, resulting in an effective means of controlling the tension for very thin strip.

For certain strip specifications, rolling in the ferritic phase can be effective. It is desirable to be able to roll either in the austenitic phase or the ferritic phase to avoid phase changes during rolling. The strip therefore has to be cooled to transform it to the ferritic phase but this must be undertaken in a very short length of strip in order to still be able to roll in the austenitic phase when cooling is not applied. Air mist cooling, a mixture of air and water, achieves the desired rapid and homogenous cooling which is needed to maintain the good shape of the strip. A subsequent extraction unit is provided (not shown) which then removes surplus water and steam from the sprayed area to prevent uncontrolled cooling of the product and unwanted steam discharges in the area of the product.

CLAIMS

1. A method for the manufacture of metal products, such as strip or lengths of rod or bar, from the molten metal to the final finished strip comprising a casting process and a rolling process, wherein the casting process produces a long strand of solidified metal, and wherein the solidified metal enters a temperature controlling furnace before it enters the rolling process, characterised in that the long strand of solidified metal is sheared before the rolling process in order to produce a strand having a long strand finite length L which corresponds to the strand length required to produce at least one discrete desired final length of finished rolled product.

2. A method according to claim 1, characterised in that the long strand length corresponds two or more discrete lengths of finished rolled product.

3. A method according to claim 1, characterised in that the long strand corresponds to between 4 and 7 discrete lengths of finished rolled product.

4. A method according to claim 1, characterised in that the long strand length corresponds to the volume of molten metal in a single ladle from which the long strand has been cast.

7. A method according to claim 1 for the manufacture of steel strip, characterised in that each strand enters the rolling process and is threaded through the rolling stands at a threading speed and that after the strand has been threaded through the rolling stands the speed is increased to a higher speed and the gauge of the strand is changed, by synchronously controlling the roll gaps and the speed of the rolling process, so that the gauge of the first discrete finished strip length is larger than the gauge of at least one subsequent finished strip length.

8. A method according to claim 7, characterised in that a gauge or shape change of the strand is achieved using dynamic shape roll (DSR®) rolls having shells which are deformable to provide a controlled profile to produce the desired flatness of the strip.

9. A method for the manufacture of metal strip or lengths of rod or bar, according to claim 1, characterised in that two casting lines are provided to provide strands for the rolling process each casting line being provided with a ladle positioning means, a casting tundish, a mould and a strand support and wherein the temperature controlling furnace is a tunnel furnace which includes at least one heat adding zone, including a temperature increasing zone and/or a temperature maintaining zone.

10. A method according to claim 1, characterised in that the rolling process includes a first rolling stage and a second rolling stage, wherein a cooling stage is provided, for steel strip, between the first rolling stage and the second rolling stage to allow the transformation of steel from the austenitic phase to the ferritic phase so that the transformation takes place before subsequent rolling.

11. A method according to claim 10, characterised in that the steel is cooled by air assisted water based cooling means.

12. A method according to claim 1, characterised in that the apparatus includes a control system with means for measuring the speed of the strip and the strands as well as a profile measuring means, a shape measuring means, and means for measuring the thickness and width of the strip and also the lateral position of the strip.

13. A method according to claim 12, characterised in that the control system is linked to temperature measuring sensors in a plurality of locations along the strand and strip as well as tension measurement means in the rolling process.

14. A method according to claim 12, characterised in that the control system is linked to a plurality of actuators in an integrated actuating system which operate in response to the measured parameters.

15. A method according to claim 12, characterised in that the speed and tension of the strip is controlled by the roll speeds, and the profile, shape, gauge, width and lateral alignment is controlled by the mould, roll gap, actuating means such as Dynamic Shape Roll (DSR®) rolls or by guide rolls.

The Patent Office

12

Application No: GB 9814683.0
Claims searched:

Examiner: A.R.Martin
Date of search: 19 August 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): B3A

Int Cl (Ed.6): B21B 1/00

Other: On line databases WPI,EDOC,JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	US 5430930 A	Italimpoanti see Fig 1	Claim 1 at least
X	US 5533248 A	Tippins see claim 1	"
X	US 5579569 A	Tippins see claim 1	"
X	US 4829656 A	SMS see claim 1	"
X	US 5611232 A	SMS see Fig 1	"
X	US 5396695 A	Danieli see Fig 1	"
X	US 5150597 A	Hitachi see Fig 2	"
X	EP 0625383 A	Danieli see Fig 2	"
X	EP 0499851 A	Danieli see claim 5	"

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☑ FADED TEXT OR DRAWING
- ☑ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: ______________________

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.